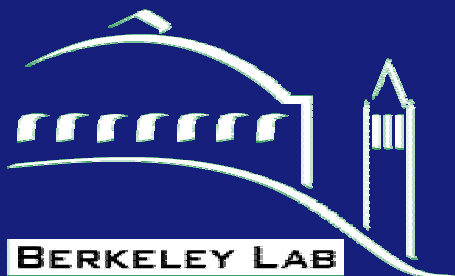


Using Benchmarking to Identify Energy Efficiency Opportunity in Cleanrooms: The Labs 21 Approach



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Preview

- ◆ Premise
- ◆ Metrics
- ◆ Use of Benchmarks to Identify Where to look
- ◆ Use of Benchmarks to Identify Opportunity
- ◆ Use of Benchmarks to set Operational Targets
- ◆ Conclusion

Benefits of Benchmarking

- ◆ Establish Baseline to Track Performance Over Time
- ◆ Prioritize Where to Apply Energy Efficiency Improvement Resources
- ◆ Identify Best Practices
- ◆ Identify Maintenance and Operational Problems
- ◆ Operational Cost Savings

Energy Benchmarking

The Premise:

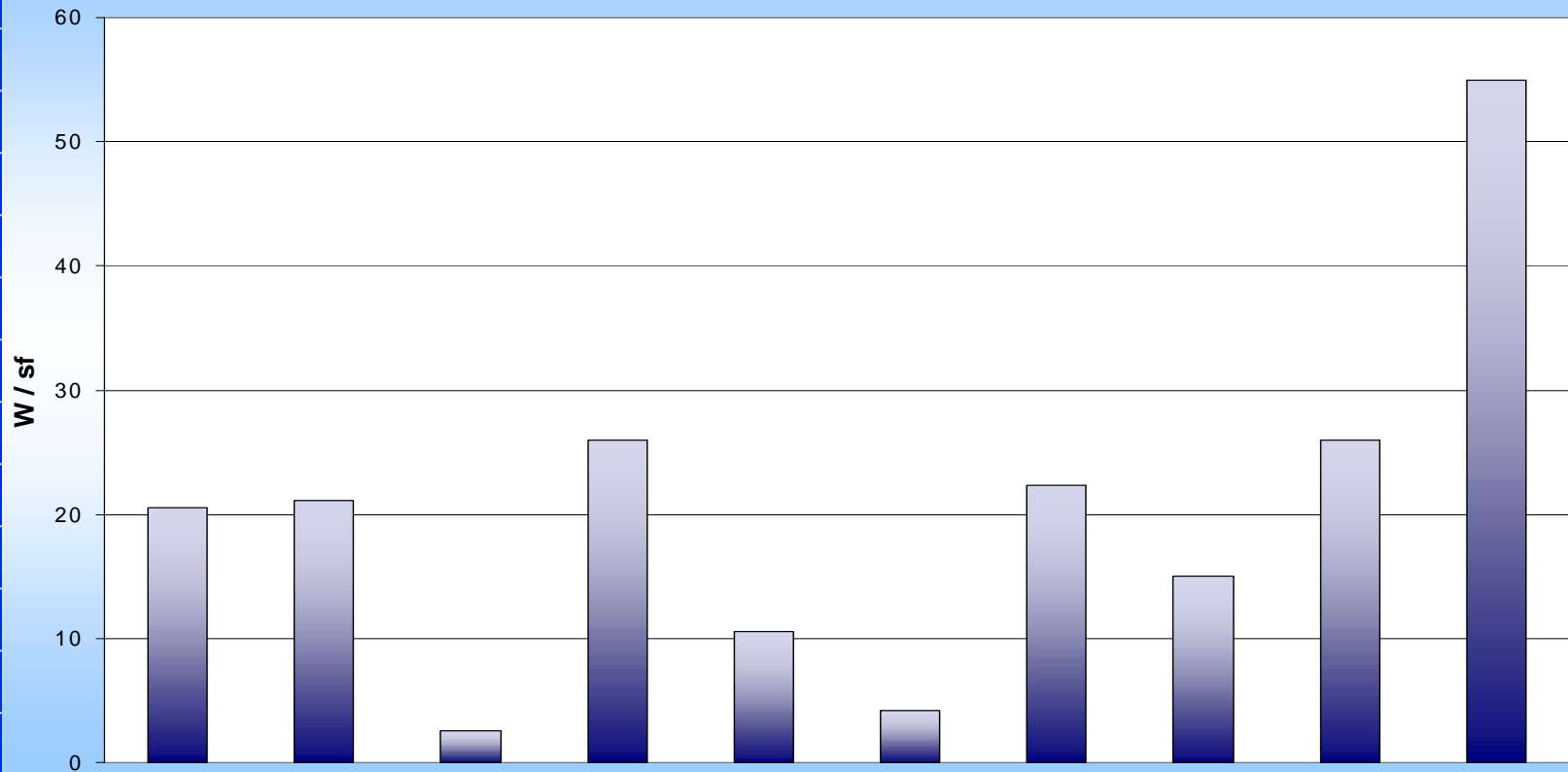
In Cleanrooms, Benchmarks of Energy End-Use and Efficiency of Key Systems Can Identify Areas for Potential Efficiency Improvement and Can Be Used to Set Operational Targets

System Efficiency vs. Production Metrics

- ◆ Compare System Efficiency
Regardless of Process
 - ◆ Production Metrics can
mask inefficient systems

Process Electrical Load Intensity

Process Load Intensity Comparison



Cleanroom HVAC metrics

- ◆ Air systems – cfm/kW
 - Recirculation
 - Make-up
 - Exhaust
- ◆ Cleanroom air changes – ACH/hr
 - Recirculated, filtered air
 - Outside air (Make-up and Exhaust)
- ◆ HEPA Air Velocity - ft/sec

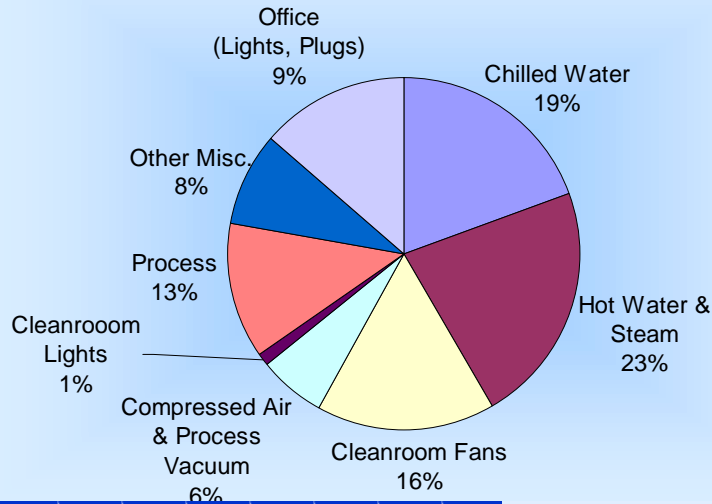
Central Plant metrics

Chilled Water Efficiency – kW/ton

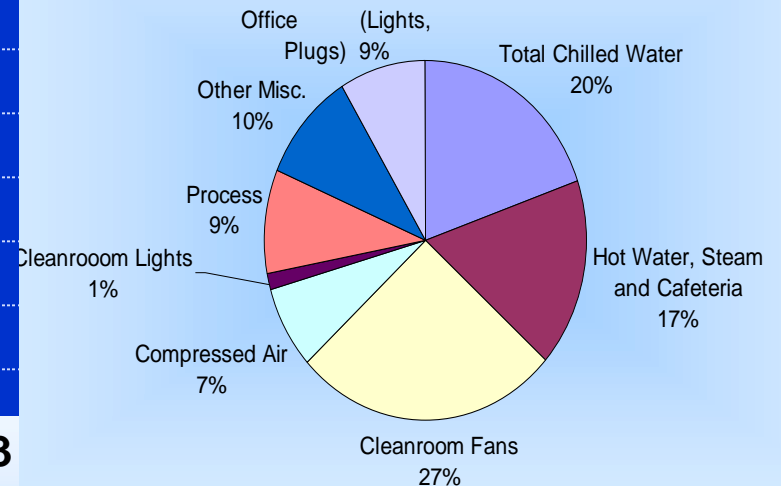
- Cooling tower/fans
- Condenser pump(s)
- Chilled water distribution pump(s)
- chiller

Energy End Use

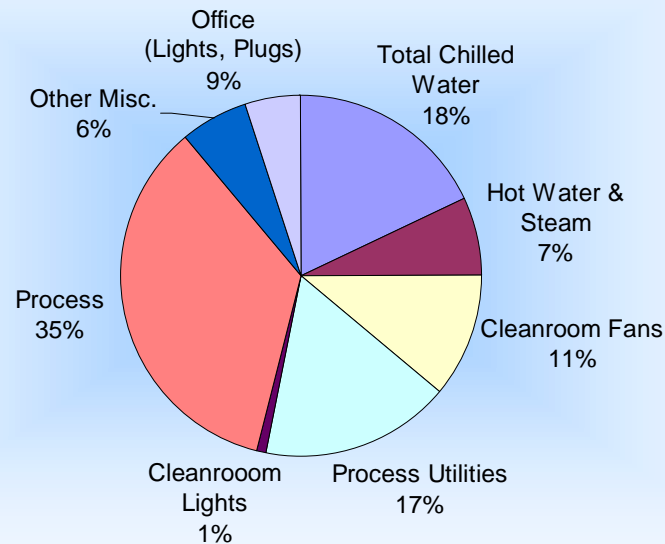
Facility 1



Facility 2

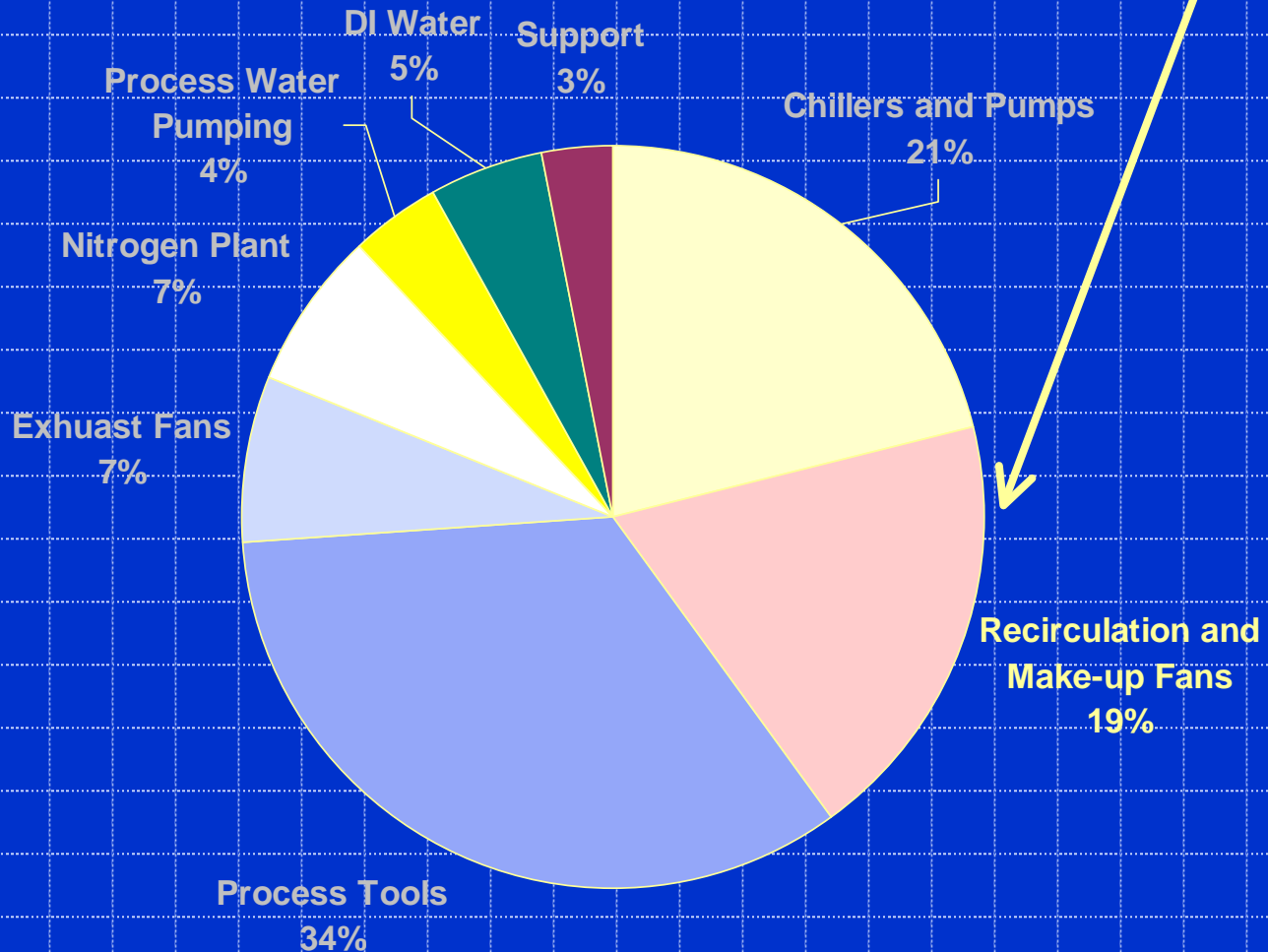


Facility 3

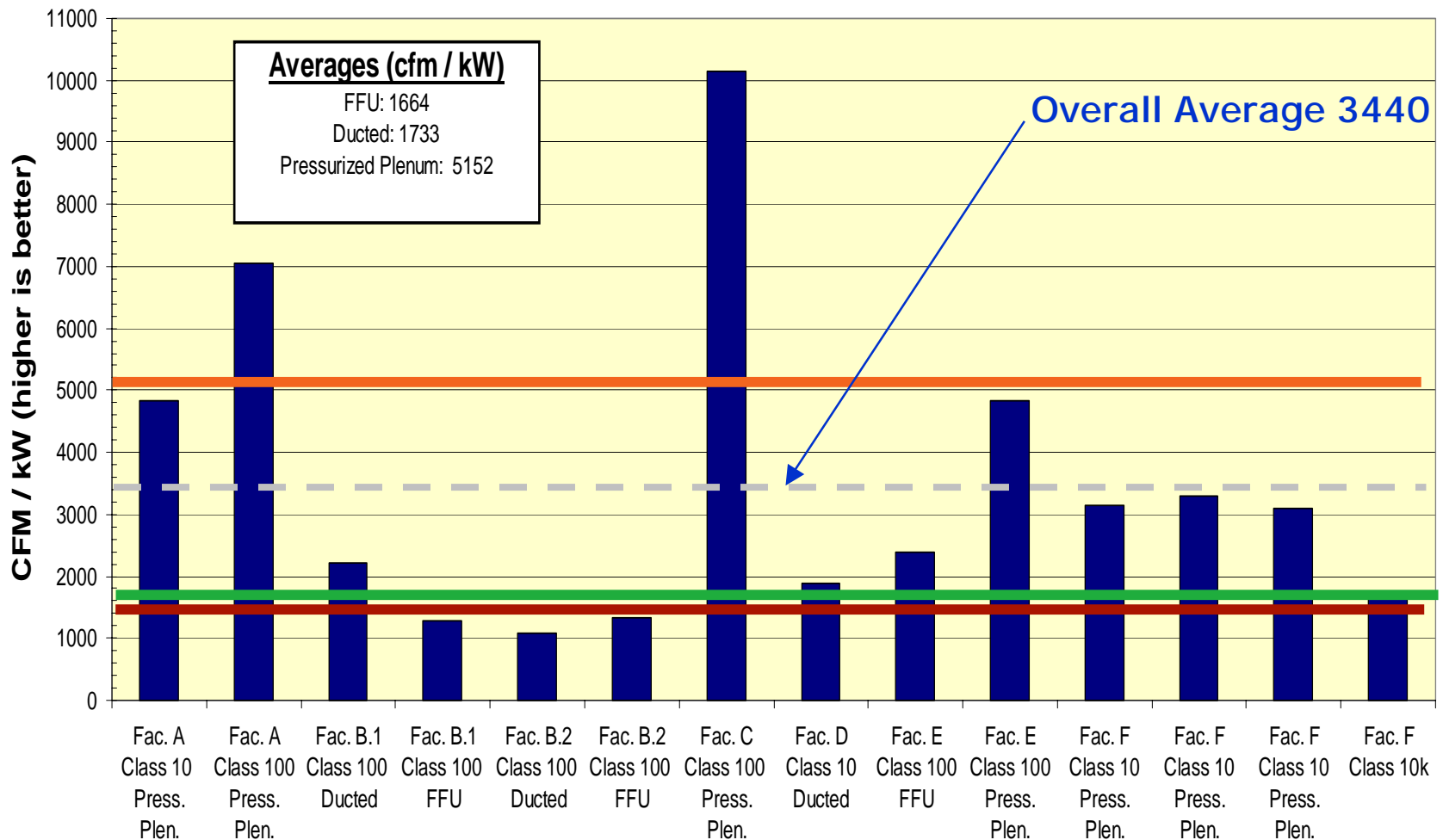


Energy Intensive systems

Recirculation of air in cleanrooms

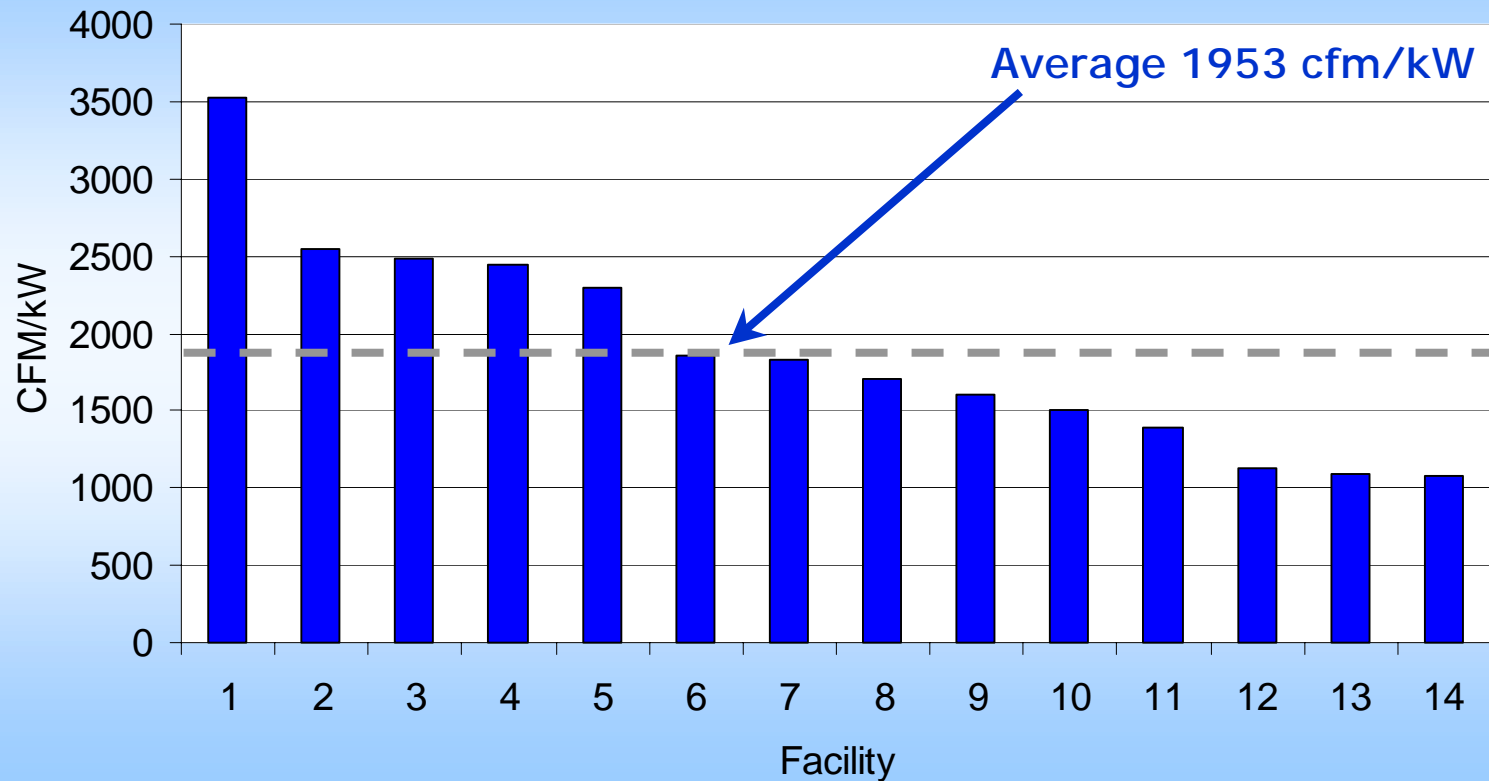


Recirculation Air Comparison



Recirculation System Efficiency – Industry Association Study

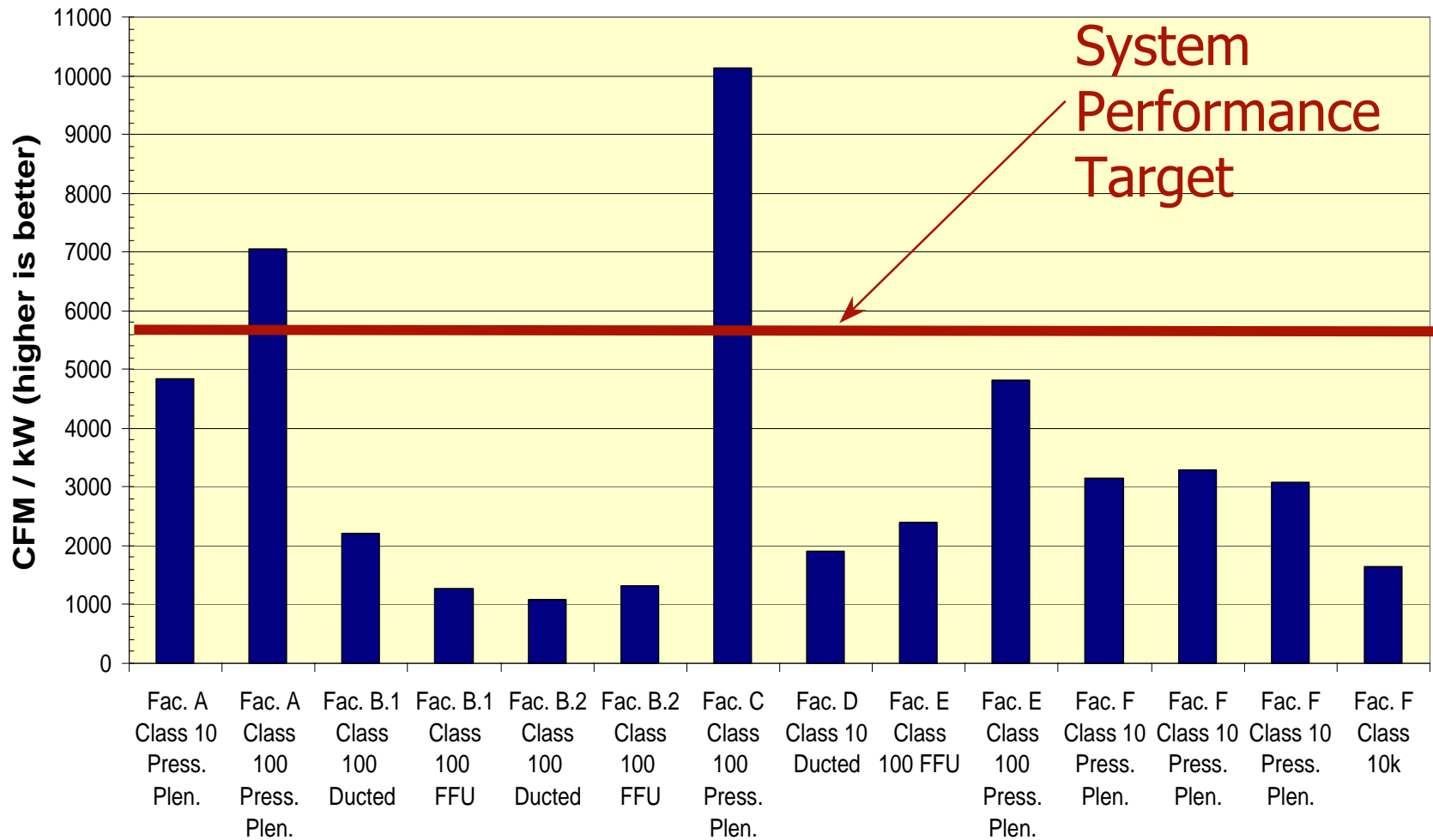
Recirculation Efficiencies



Using Benchmarks To Set Goals

Building Owners and Designers can use benchmark data to set energy efficiency goals.

Recirculation System Target



Looking Within the System...

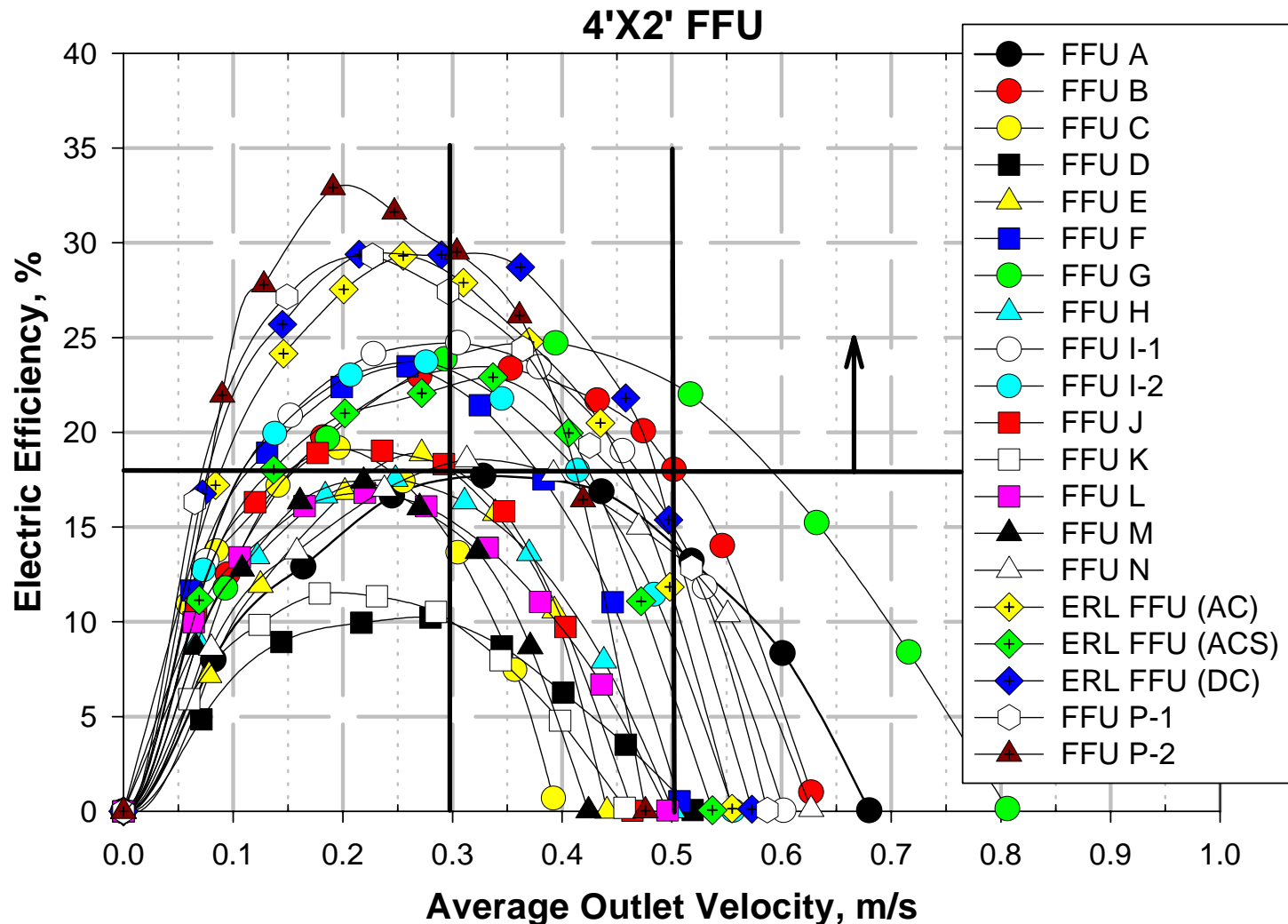
HVAC Efficiency Choices are Many

- ◇ Equipment – Fans, Motors, Chillers, Controls, Filters, floor systems
- ◇ System Pressure Drop – face velocity, duct velocity, chases, plenums, adjacency, layout
- ◇ Air change rates
- ◇ Ceiling coverage

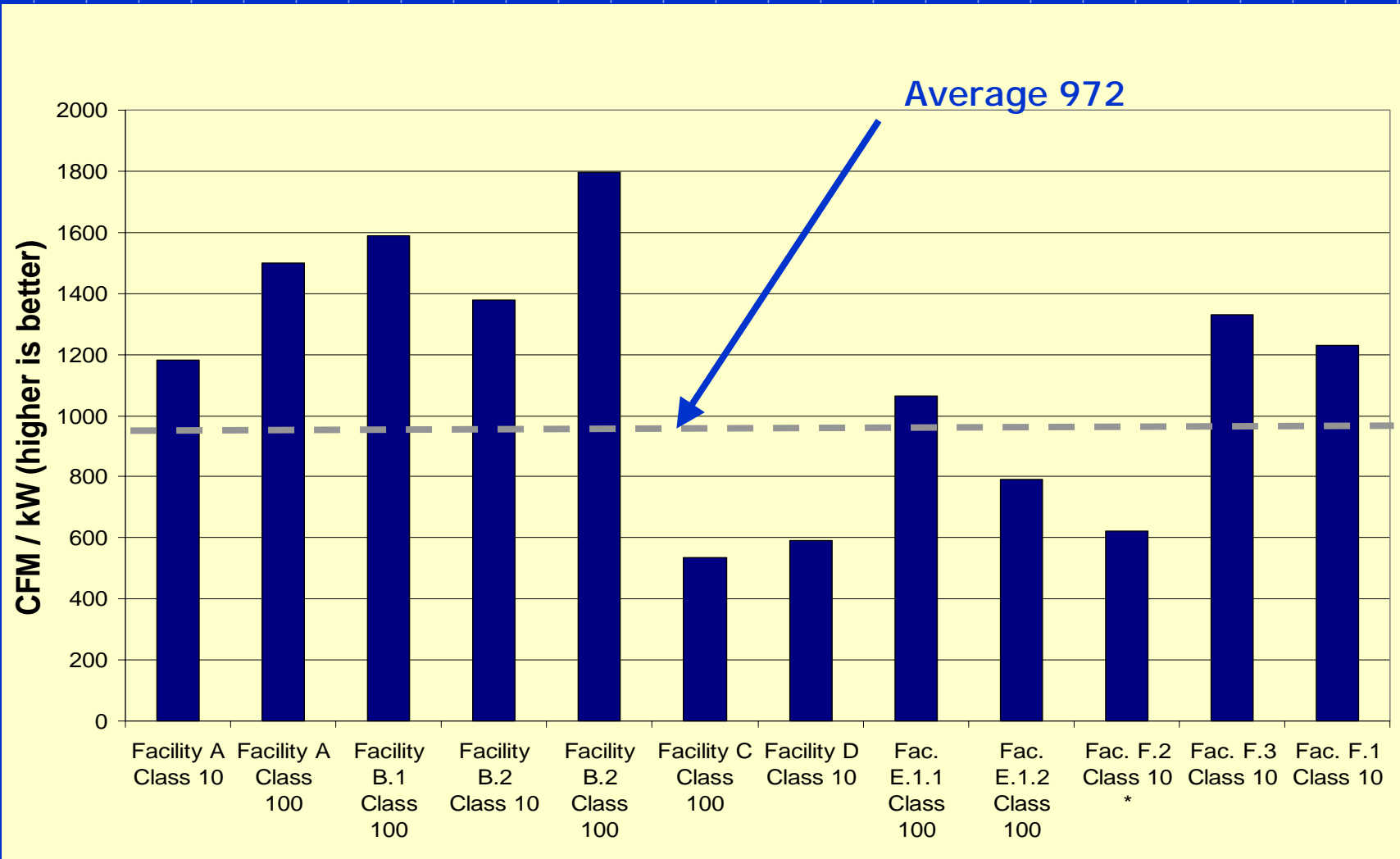
Here's one Choice: Ducted HEPA Filters



Fan-Filter Unit Electrical Efficiency Comparison

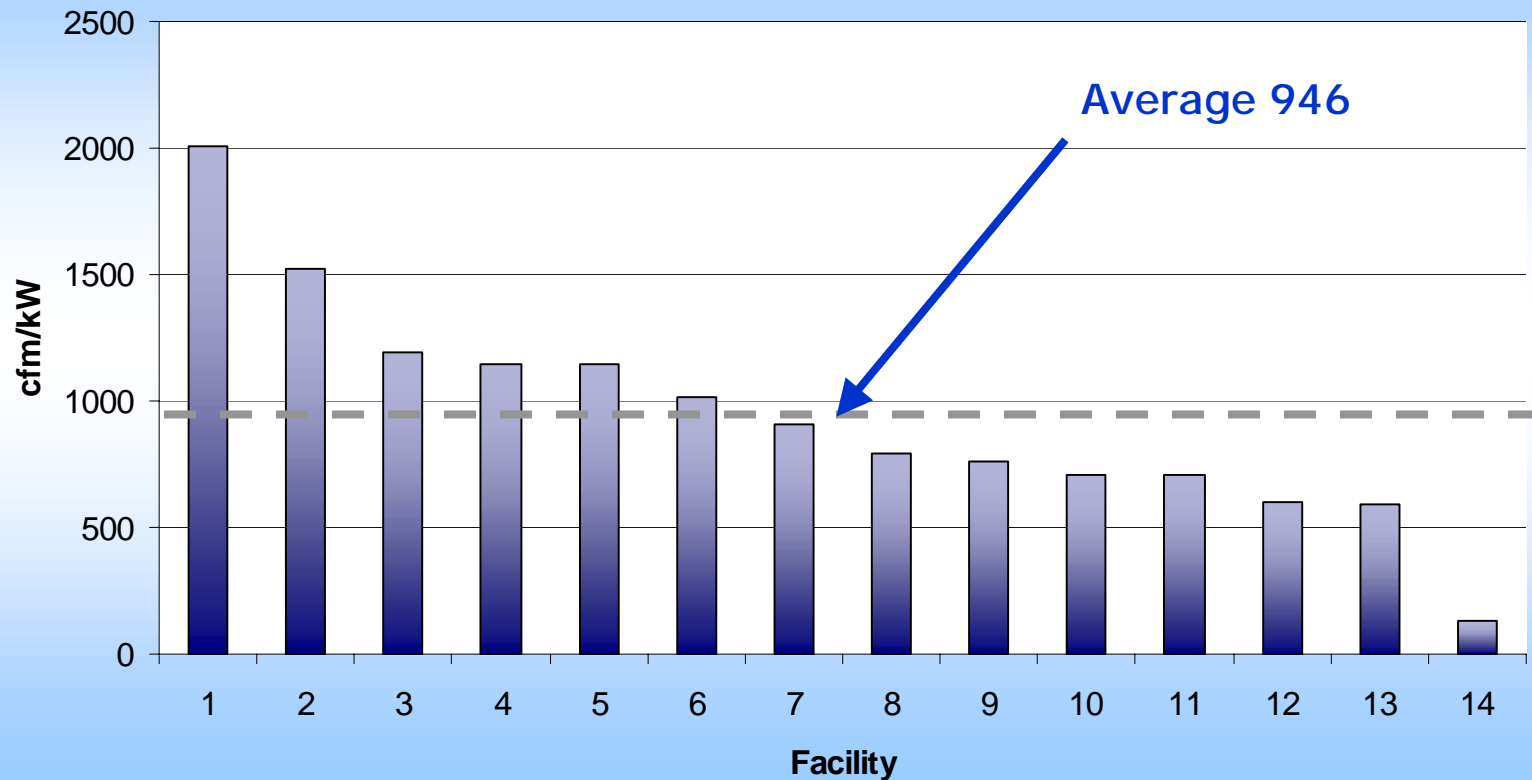


Make-up Air Comparison



Make-up Air Efficiency – Industry Association Study

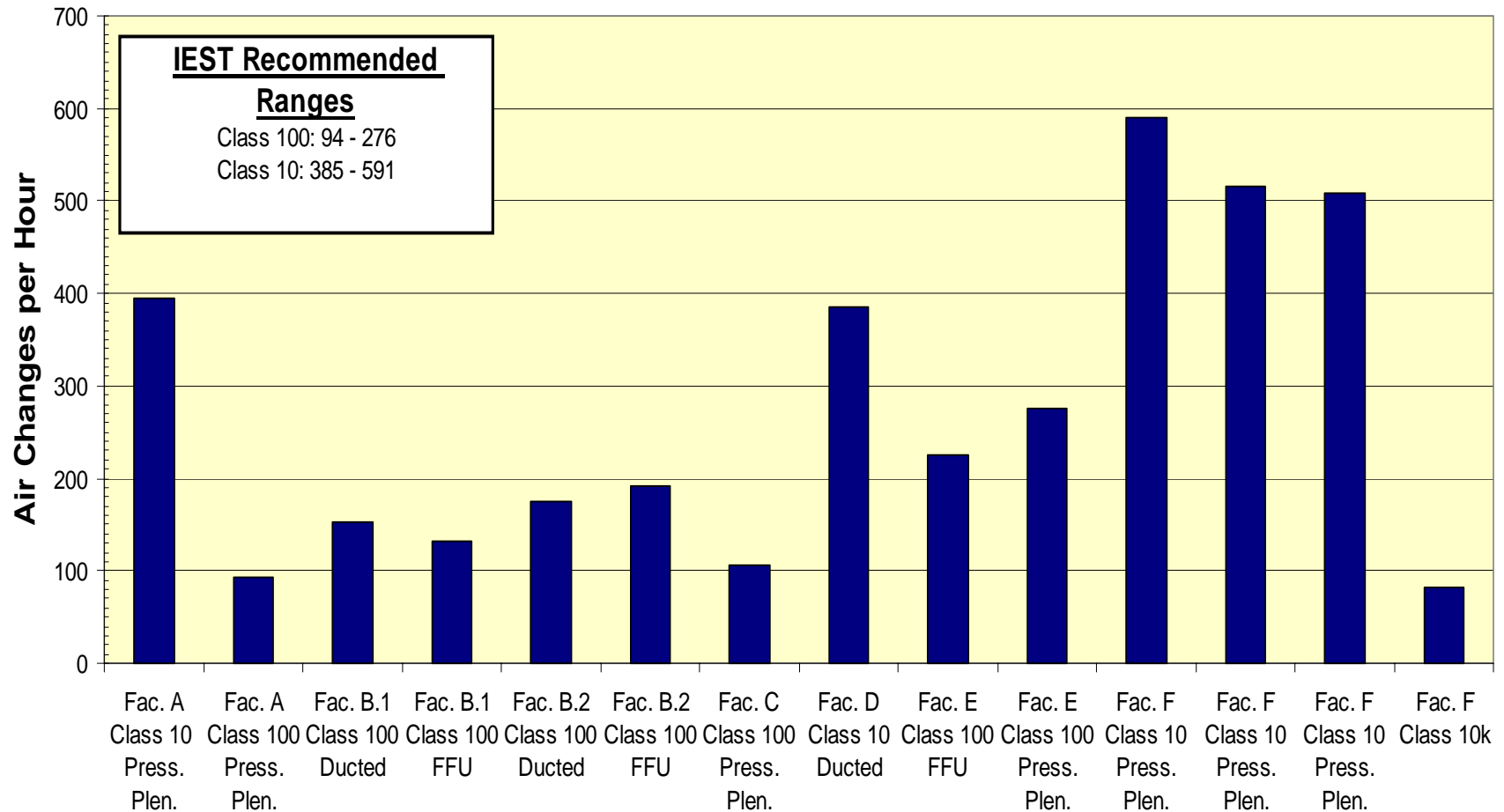
Make-up Air Energy Efficiency



Make-up System Efficiency Choices

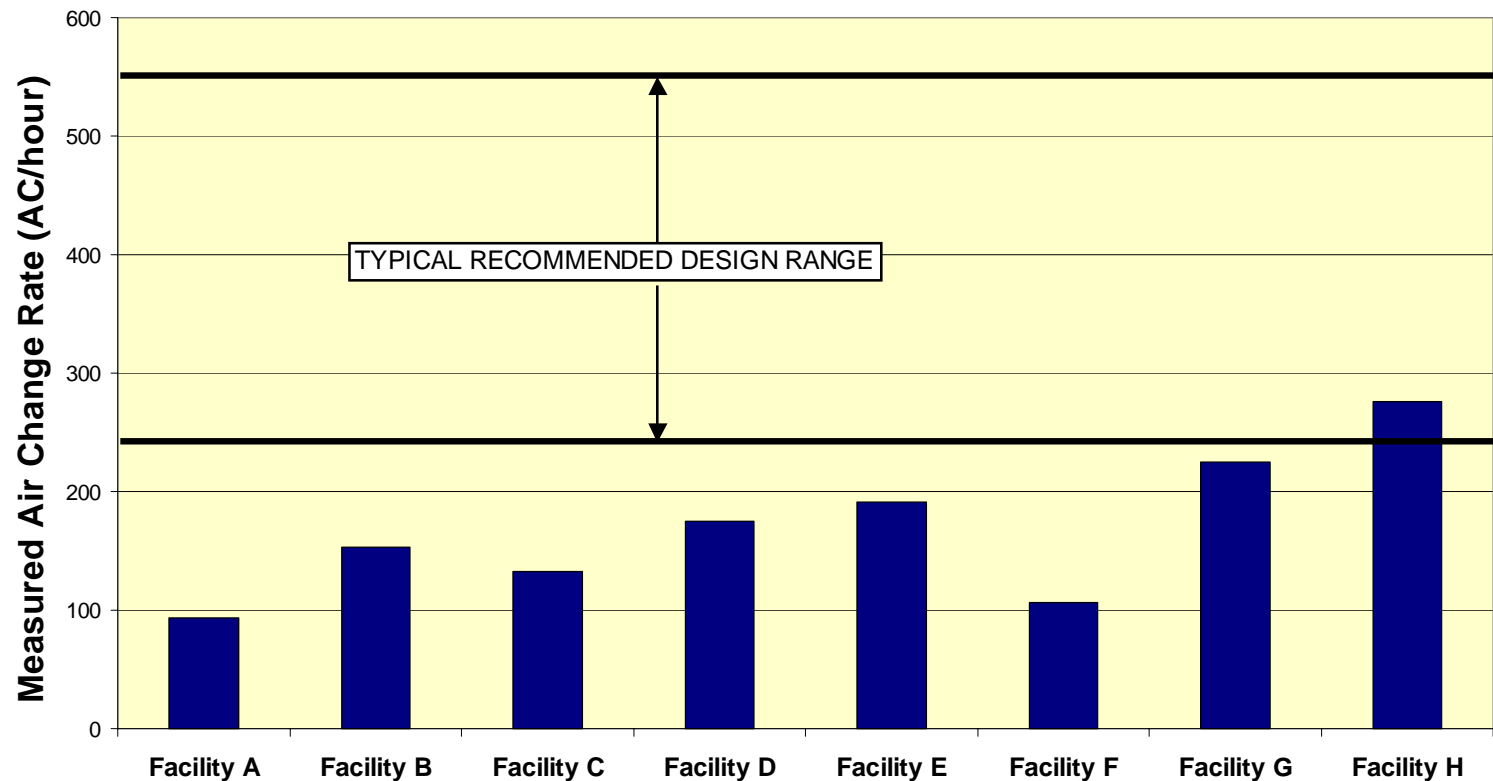
- ◆ Adjacency of air handler(s) to cleanroom
- ◆ Resistance of make-up air path
- ◆ Pressurization/losses
- ◆ Air handler face velocity
- ◆ Coil Pressure Drop
- ◆ Fan and motor efficiency
- ◆ Variable Speed

Air-Change Rate Comparison



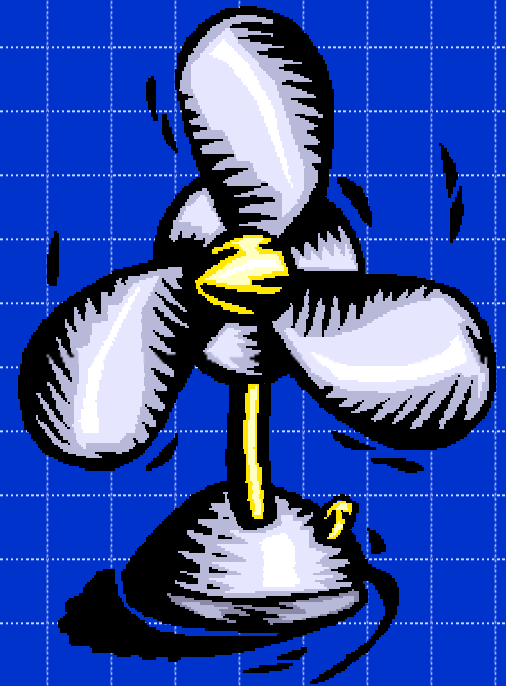
A Closer Look at Air Change Rates

Cleanroom Benchmarking Data
ISO Class 5 (Class 100) Cleanrooms

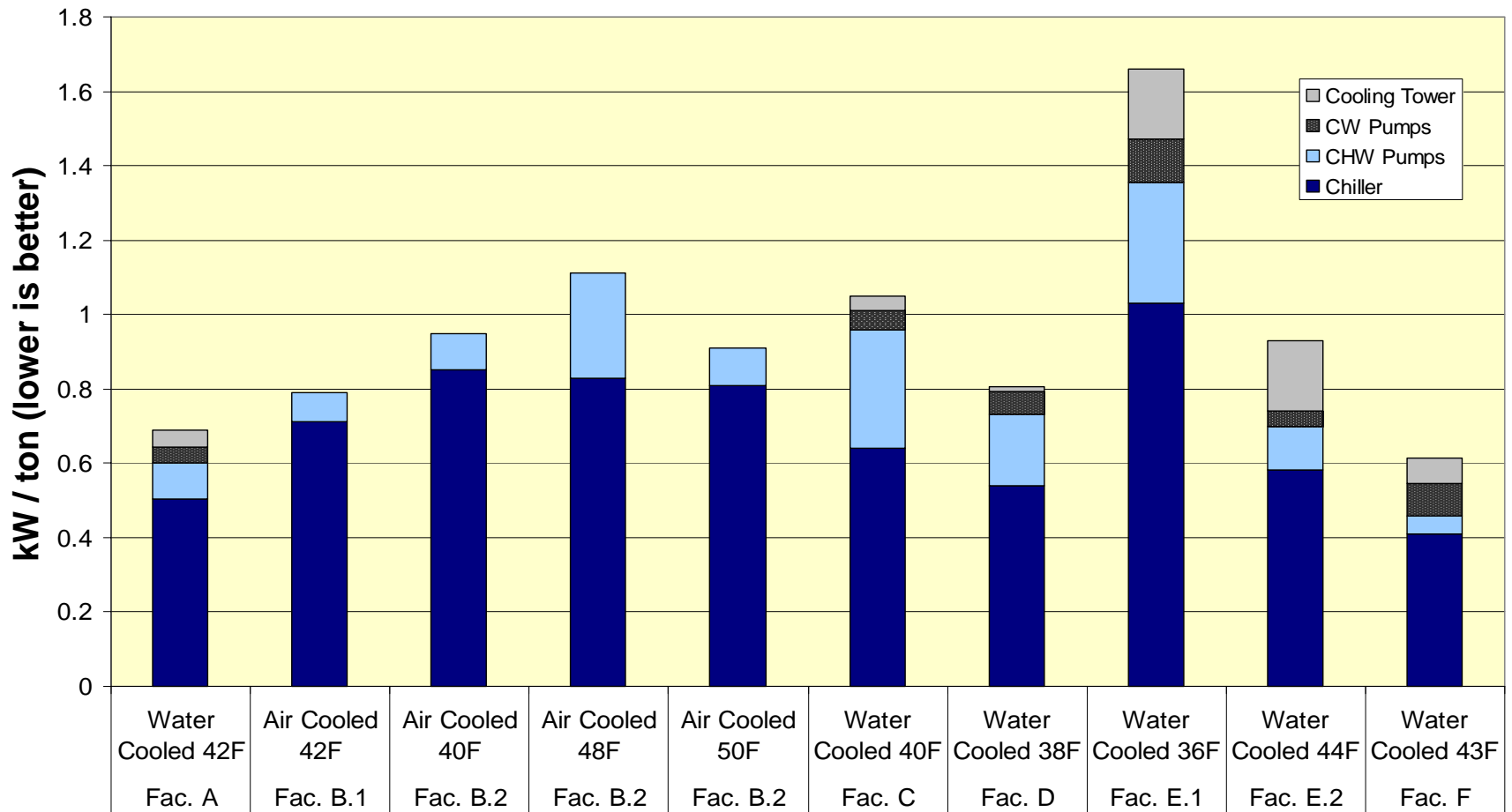


Air Change and Velocity Choices

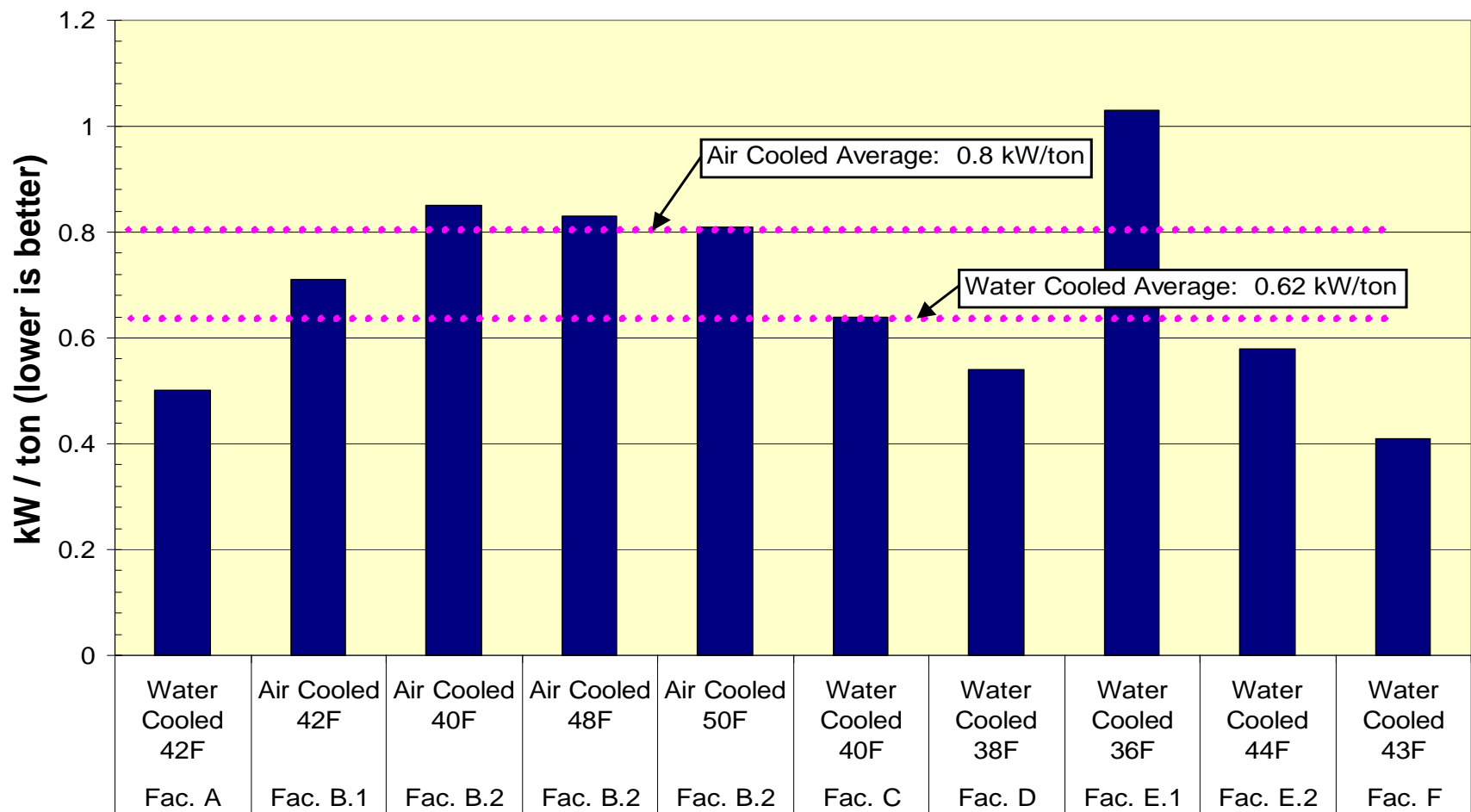
- ◆ IEST Recommended Recirculation Air Change Rates
- ◆ Variable Speed Fans (start low with ability to increase)
- ◆ Ceiling Coverage
- ◆ Pressurization/Losses



Chilled Water Systems Comparison



Chiller Comparison



Chilled Water System Choices

- ◆ Free Cooling
- ◆ Chiller Efficiency
- ◆ Variable Speed Chiller
- ◆ System Pressure drop
- ◆ Primary only or primary/secondary
- ◆ System controls
- ◆ Efficient Pumping
- ◆ Water vs. Air Cooled



Labs 21 Also Recognizes the Non-energy Benefits of Benchmarking

- ◆ Reliability Improvement

- Controls
- Setpoints

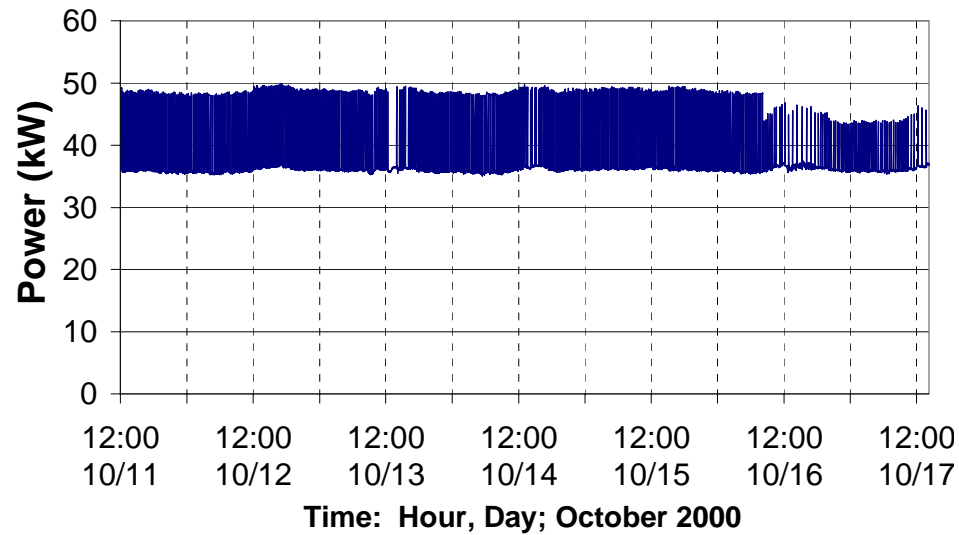
- ◆ Maintenance

- Leaks
- Motors, pumps, Fans
- Filters
- Chillers, boilers, etc.

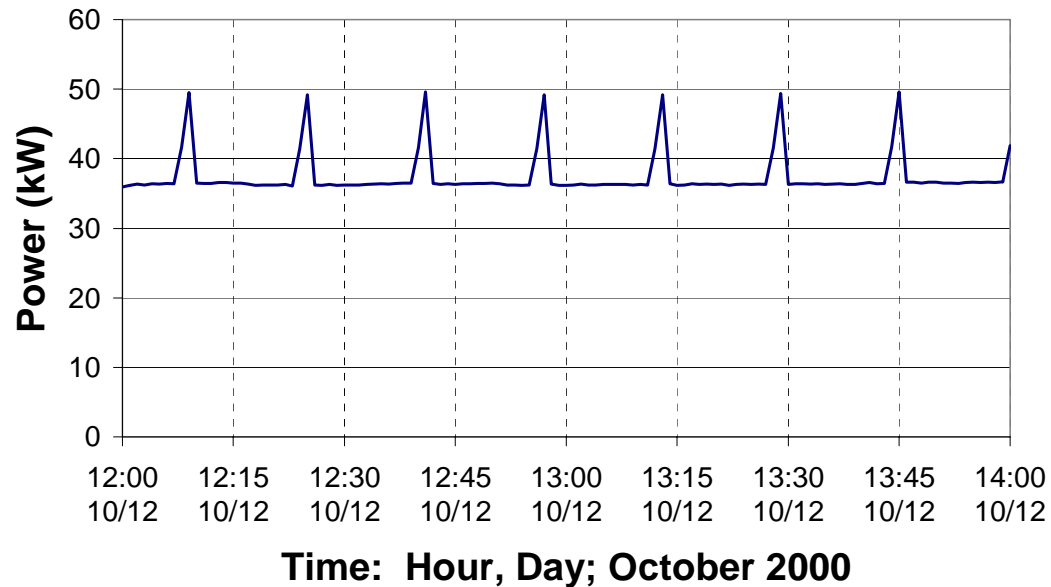
- ◆ Safety

- Hazardous air flow

Chilled Water Pump Power



Chilled Water Pump Power



Goal Setting Based Upon Benchmarks

- ◆ Facility and End Use “Energy Budgets”
- ◆ Efficiency Targets and/or Design Requirements for Key Systems and Components
 - Cfm/KW
 - KW/ton
 - System resistance – i.e. Pressure drop
 - Face velocities
 - Etc.

Cleanroom Benchmarking highlights some important issues

- ◆ Contamination Control Can Often Be Obtained With Reduced Air Change Rates
- ◆ Cleanliness Rating is Often Higher Than Needed
- ◆ Existing Guidance for Chilled Water Systems is Under-utilized
- ◆ Criteria Based Upon Rules Of Thumb Should Be Examined (90ft/min, air change rates, etc.)

Conclusion

- ◆ Benchmarking Can Be Used To Find Efficiency Opportunity
- ◆ Building Owners, Operators, and Designers Can Use Benchmarks to Set Criteria
- ◆ More Robust Data is Needed To Identify All Current Best Practices
- ◆ If You Have Benchmark Data – Share It!